Origin and evolution of arthropod visual systems

Stavenga, Doekele G.; Harzsch, Steffen

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Editorial

Origin and evolution of arthropod visual systems: Introduction to Part II

Of the various animal phyla, the Arthropoda are perhaps the most intriguing from an evolutionary perspective. The arthropods have conquered all imaginable habitats, and their forms and functions are diverse and often bizarre. The visual systems of arthropods are similarly varied, and it is thus a formidable challenge to understand their origins as well as their radiation. In the 1980s and 1990s, combined anatomical and optical research has gained much insight into the structure and function of animal eyes, especially those of arthropods (Land and Nilsson, 2002; Warrant and Nilsson, 2006). The organization of visual neuropils is also gaining some understanding in the context of its possible evolution (Strausfeld, 2005). Nevertheless, many groups of researchers still have rather narrow perspectives in trying to understand the functional organization of the arthropod visual systems, focusing mainly on a mere handful of insect taxa and the occasional spectacular malacostracan. It is our hope that this volume, like its predecessor, will significantly broaden the horizon for future researchers. We are, therefore, very pleased that the editors of Arthropod Structure and Development have granted a second issue devoted to this exciting research field.

The first special issue (Part I), published a year ago, contained contributions on the visual systems of taxa as diverse as the Annelida (representing a potential arthropod outgroup), the fossil Trilobita, the xiphosuran *Limulus polyphemus*, some Crustacea, and the fruit fly *Drosophila melanogaster*, as well as hymenopteran and lepidopteran insects, together with reviews on molecular and developmental aspects. It is the aim of the present issue (Part II) to cover a similarly broad range of taxa and topics.

In the first paper, Nilsson and Kelber review the structure of arthropod compound eyes, and they expound the challenging thesis that compound eyes have evolved along two parallel lines. Namely, they suggest that the ancestors of the well-studied compound eyes of crustaceans and insects had focusing crystalline cones, and that the eyes of the ancestors of the myriapods and chelicerates had corneal lenses.

Oakley and co-workers offer a new perspective on the evolution of arthropod photoreceptors from a developmental perspective, and they specifically focus on the importance of gene-duplication, divergence and regulatory mutation.

Subsequently, Greven introduces the eyes of Tardigrada, a taxon with unclear phylogenetic position with regard to other Arthropoda; but this special group of animals can function nevertheless to illuminate some general properties of arthropod visual systems. Together with the papers on Onychophora and Annelida in Part I, the contribution by Greven provides insights into how the visual system in the arthropod stem lineage might have looked like.

Reimann and Richter elaborate on the topic treated by Elofsson (2006) in Part I, who discussed the nauplius (and other frontal) eyes of crustaceans, which strongly differ from the compound eyes. The present study shows that the clam shrimps provide crucial insight into the evolutionary relationship of nauplius eyes in non-malacostracan crustaceans.

The contribution on the amazing eyes of stomatopod crustaceans by Marshall and co-workers provides an up-to-date account of extensive knowledge that has been gained in the last decade on this quintessentially visual group of crustaceans. Their eyes are unique with respect to the richness of their population of color-coded receptors that occupy a mid-band of the compound eye and with regard to their high spatial acuity. Photoreceptor arrangements of the mantis shrimp eye are such that each eye may provide binocular input, even a trinocular one if the mid-band receptors are included. These wonderful eyes have been a constant revelation for the visual community, but compared to other species little is known about their visual ganglia. As indicated in this review, that may soon change.

The paper by Sbita and co-workers presents novel data on developmental changes in the eye and optic lobe of *Thermonectus marmoratus*, an aquatic beetle. This study is one of the rare investigations on the changes occurring during the transition of visual brain regions during metamorphosis.

Lastly, Müller and co-workers present new and comprehensive information on the visual system of an important taxon of myriapods, the bristly millipedes (Penicillata). They nicely illustrate their visual system and present a challenging new hypothesis on the evolutionary significance of the millipede eye, which is particularly interesting in the light of the opening paper by Nilsson and Kelber.

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The set of papers assembled here and in Part I cannot be an exhaustive or comprehensive treatment of the evolution and development of arthropod visual systems as there are still a number of issues that have not yet been dealt with. Nevertheless, these papers again show that ongoing research is vibrant, and new insights into this field are happening apace. Taken together, the two special issues on arthropod vision leave in no doubt the fertility and value of comparative studies and the deepening knowledge of the evolutionary process.

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Doekele G. Stavenga*
University of Groningen, Department of Neurobiophysics, Nijenborgh 4, 9747 AG Groningen, The Netherlands
*Corresponding author. Tel.: +31 50 363 4785; fax: +31 50 363 4740.
E-mail address: d.g.stavenga@rug.nl

Steffen Harzsch
Max-Planck-Institute for Chemical Ecology, Department of Evolutionary Ecology, D-07745 Jena, Germany
E-mail address: sharzsch@ice.mpg.de